Supporting Text

Calculus of Sound Power Transmission Through the External and Middle Ear. In the work of Rosowski (1, 2) the effective area at the oval window is defined as the parameter that accounts for the power loss in the external and middle ears, according to the following expression:

$$EA_{OW}^{PW}(\phi,\theta) = \frac{Power\ into\ the\ Inner\ Ear}{Intensity\ of\ the\ Incident\ Plane\ Wave} = EA_{TM}^{PW}(\phi,\theta)\cdot MEE \qquad \textbf{[1]}$$

Where EA_{TM}^{PW} defines the effective area at the tympanic membrane as the ratio between the power into the middle ear and the intensity of the incident plane wave.

$$EA_{TM}^{PW} = \frac{Power\ into\ the\ Midle\ Ear}{Intensity\ of\ the\ Incident\ Plane\ Wave} = \left|\frac{P_T}{P_{PW}}(\phi,\theta)\right|^2 \frac{\rho_0\, c\, Re\{Z_T\}}{|Z_T|^2} \qquad \textbf{[2]}$$

On the other hand, MEE is the middle-ear efficiency that quantifies how much of the power entering the middle ear actually reaches the inner ear.

$$MEE = \frac{Power\ into\ the\ Cochlea}{Power\ into\ Middle\ Ear} = \left|\frac{U_S}{P_T}\right|^2 \frac{|Z_T|^2\ Re\{Z_C\}}{Re\{Z_T\}} \qquad \textbf{[3]}$$

By using Eqs. **1**, **2**, and **3**, the effective area of the oval window can be calculated according to the following expression:

$$EA_{OW}^{PW}(\phi,\theta) = \left|\frac{U_S}{P_{PW}}(\phi,\theta)\right|^2 Re\{Z_C\}\ \rho_0 c \qquad \textbf{[4]}$$

If the gain produced by diffraction and scattering about the head and the radiation impedance looking out from the ear opening into the environment are both inconsiderable, the effective area of the oval window can be calculated as follows:

$$EA_{OW}^{PW} = \frac{1}{\left|AZ_C + B\right|^2} \, Re\left\{Z_C\right\} \, \rho_0 c \qquad \textbf{[5]}$$

In the expressions above, Z_T is the impedance at the tympanic membrane, Z_C is the impedance at the cochlea, ρ_0 is the static density of air, *c* is the propagation velocity of sound, *A* and *B* are transmission parameters of the external and middle ears equivalent circuit, P_T is the sound pressure at the tympanic membrane, P_{PW} is the sound pressure of the incident plane wave, and U_S is the volume velocity at the stapes.

Technical Data on the Computed Tomography (CT) Scans. The left tympanic plate of Cranium 5 was originally recovered isolated from its temporal bone, making it possible to directly measure certain dimensions of the middle and external ears. The CT scans of this specimen were taken after attaching the tympanic plate to its temporal bone by using a Toshiba helical CT scanner, obtaining a total of 136 images of 512 × 512 pixels and 16 bits grey levels. The slice thickness is 1 mm, and the slice increment is 0.2 mm (field of view = 82.432 mm, kVp[1] =120, pixel size = 0.1610 mm).

The CT scans of the right temporal bone AT-1907 and left temporal bone AT-4103 were obtained by using a General Electric LightSpeed 16. We obtained, respectively, a total of 211 and 262 images and 16 bits grey levels; the slice thickness is 0.625 mm, and the slice increment is 0.2 mm in both temporals (AT-1907: field of view[2] = 96 mm, kVp 120, pixel size = 0.1875 mm) (AT-4103: field of view = 128 mm, kVp 120, pixel size = 0.25 mm).

The CT scans of the left temporal bone of the chimpanzee were obtained by using a General Electric HiSpeed CT scan, obtaining a total of 201 images of 512 × 512 pixels and 16 bits grey levels. The slice thickness is 1 mm, and the slice increment is 0.2 mm (field of view = 76 mm, kVp =120, pixel size = 0.1484 mm).

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[1] ?/Au: Is it correct that "kVp" stands for "kilovolt peak"?

Theoretical Modelling of the "Human-Like" Chimpanzee and the "Chimpanzee-Like" Modern Human Individuals. Relative to modern humans, chimpanzees are characterized by (*i*) larger values in tympanic membrane area, functional length of the malleus, and length of the external auditory canal (6), and (*ii*) smaller values in stapes footplate area, functional length of the incus (6), and mass of the malleus–incus complex (7). Although there are no published data on the cross-sectional area of the external auditory canal (A_{EAC}) in chimpanzees, the available information on the cross-sectional area of the external auditory meatus (which is not the same measurement as our A_{EAC}) suggests that the external auditory canal is wider in modern humans than in chimpanzees (8). Our measurements of A_{EAC} on a Medieval modern human sample (range = 27.8–56.7 mm^2) also suggest that this area is greater in modern humans than in chimpanzees (20.4 mm^2 in the chimpanzee we have measured through 3D CT reconstruction).

Accordingly, we have modelled our theoretical "human-like" chimpanzee (Table 6) using values that are two standard deviations below the chimpanzee mean provided by Masali *et al.* (6) in the tympanic membrane area and the functional length of the malleus. Similarly, we have used values that are two standard deviations above the chimpanzee mean provided by Masali *et al.* (6) in the stapes footplate area and in the functional length of the incus. For the length of the external auditory canal, we have used the minimum value in Masali *et al.* (6) because they do not provide standard deviations for this variable. For the mass of the malleus–incus complex and the cross-sectional area of the external auditory canal, for which data on chimpanzee variability is lacking in the literature, we have used the mean values for modern humans provided by Rosowski (3), even though this actually overestimates the chimpanzee variation toward modern humans.

We have followed a similar procedure to produce a theoretical "chimpanzee-like" modern human individual varying the measurements so that they approach more closely the chimpanzee pattern (Table 6). In the stapes footplate area and the functional length of the incus, we have used values that are two standard deviations below the modern human mean provided by Masali *et al.* (6). For the tympanic membrane area and functional length of the malleus, we have used values that are two standard deviations above the modern human mean in Masali *et al.* (6). Because Masali *et al.* (6)

[2] ?/Au: Is it correct that "FOV" stands for "field of view"?

do not provide standard deviations for the length of the external auditory canal, we have used a value that is two standard deviations above the mean measured in our Medieval human sample (mean = 23.7 mm, SD = 2.6 mm). For the mass of the malleus–incus complex, we have used a value which is two standard deviations below the mean for adult individuals provided in Kirikae (9). Finally, for the cross-sectional area of the external auditory canal we have used a value that is two standard deviations below the modern human mean recorded in our Medieval sample (mean = 41.56 mm^2, SD = 7.73 mm^2).

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